DOCUMENT RESUME

ED 296 894 SE 049 433

AUTHOR Gowdy, Vickie L.
TITLE Females and Mathematics: Factors Influencing Their Participation and Achievement.
PUB DATE 88
NOTE 58p.; Master's Exit Project, Indiana University at South Bend.
PUB TYPE Dissertations/Theses - Master Theses (042) -- Reference Materials - Bibliographies (131) -- Information Analyses (070)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS College Mathematics; Educational Research; Elementary School Mathematics; Elementary Secondary Education; *Females; *Mathematics Achievement; *Mathematics Anxiety; Mathematics Education; Mathematics Instruction; Secondary School Mathematics; *Sex Differences; Sex Role; *Sex Stereotypes; Student Motivation; Student Participation
IDENTIFIERS Mathematics Education Research

ABSTRACT

It is a concern of many educators and researchers that females are underrepresented in the field of mathematics and careers that require mathematics. This study begins with a review of the literature that examines the sex-related differences in mathematics. Three major categories involving the relationship between females and mathematics are then examined and discussed. These categories are the factors influencing participation of females in mathematics, the factors influencing achievement of females in mathematics, and intervention programs to increase achievement and participation of females in mathematics. An annotated bibliography of the literature in each category is provided and summarized. Conclusions and recommendations are given for increasing participation and achievement of females in mathematics based on the factors identified in the summary. (PK)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED296894

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Vickie L. Gowdy

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

FEMALES AND MATHEMATICS:

FACTORS INFLUENCING THEIR PARTICIPATION AND ACHIEVEMENT

Written by Vickie L. Gowdy

Indiana University at South Bend

Master's Exit Project

Summer 1988

Supervised by Charles R. DuVall, Ph.D.

SE049 433

TABLE OF CONTENTS

Introduction.....1

Statement of the Problem.....2

Limitations of the Study.....3

Definition of Terms.....4

Annotations: Introduction.....7

Annotations: Factors Influencing Participation of Females in Mathematics.....9

Annotations: Factors Influencing Achievement of Females in Mathematics.....23

Annotations: Intervention Programs.....33

Summary.....39

Conclusions.....46

Recommendations.....47

Bibliography.....48

INTRODUCTION

It is a concern of many educators and researchers that females are underrepresented in the field of mathematics and careers that require mathematics (Armstrong and Price, 1982: 99; Becker, 1981: 40; Blackman, 1986: 33; Bleyer, Pedersen, and Elmore, 1981: 47; DeBoer, 1984: 95; Fennema et al., 1981: 3; Sherman, 1982b: 428; Thomas, 1986: 31). This study began with a review of the literature that examined the sex-related differences in mathematics. Three major categories involving the relationship between females and mathematics were then examined and discussed. These categories were the factors influencing participation of females in mathematics, the factors influencing achievement of females in mathematics, and intervention programs to increase achievement and participation of females in mathematics. An annotated review of the literature in each category was provided and summarized. Conclusions were derived and recommendations were given for increasing participation and achievement of females in mathematics based on the factors identified in the summary.

STATEMENT OF THE PROBLEM

Increasing female participation and achievement in mathematics is essential to the equalization of educational and career opportunities between the sexes (Armstrong and Price, 1982: 99; Becker, 1981: 40; Blackman, 1986: 33; Bleyer, Pedersen, and Elmore: 1981; DeBoer, 1984: 95; Fennema et al., 1981: 3; Sherman, 1982b: 428; Thomas, 1986:31).

LIMITATIONS OF THE STUDY

It has been well documented that by end of high school there are significant differences in mathematics achievement favoring males (Armstrong, 1981; Fennema and Carpenter, 1981; Hilton and Berglund, 1974; Pallas and Alexander, 1983; Sherman, 1980). An obvious area of concern when examining these sex differences in mathematics is the possible innate ability of males to do mathematics better than females. However, most of the research on females and mathematics that has been conducted in the last decade has focussed on the possible social-psychological variables that may be effecting the participation and achievement of females in mathematics. The conclusions of this paper are limited by the fact that this study does not address any biological varibles that may effect the participation and achievement of females in mathematics.

DEFINTION OF TERMS

androgynous: a person whose interests and activities are both masculine and feminine (Parsons, 1981: 8).

attitude scales: "measures that assess the feelings negative or positive of an individual toward some psychological object" (Dejnozka and Kapel: 46).

attributions: "the kinds of explanations people give for their successes and failures" (Covington and Beery: 67).

avoidance: "a particular action or response causes the cancellation or postponement of an event that would otherwise have occurred" (Harre and Lamb: 49).

desensitization: "the pairing of deep muscle relaxation with invitro mathematics anxiety arousing situations." (Trent, 1985: 2).

effectance motivation: "a commitment to follow through on math problem solving activities" (Pedersen, Bleyer, and Elmore, 1985: 45).

electors: "students who chose to continue the study of math beyond requirements for high school graduation or college entrance" (Perl, 1982: 68).

father, mother, and teacher scales: "measures of perceived attitudes of important others toward one as a learner of mathematics" (Fennema and Sherman, 1977: 53).

feedback: "the process whereby the individual gains information concerning the correctness of previous responses so the behavior can be adjusted to compensate for errors" (Good: 238).

Fennema-Sherman Mathematics Attitudes Scales: attitudes scales developed by Fennema and Sherman (Fennema and Sherman,1977: 53).

gender: "a social, cultural, and psychological creation by which a girl or boy learns what society expects them to do, think, and feel" (Skolnick, Langbort, and Day: 8).

hypnotherapeutic restructuring: a treatment involving four constructs "(a) to teach focus of attention and ego strengthening, (b) to relate mathematical concepts and experiences to the individual's environment, (c) to build positive associations to numbers and testing situations, and (d) to restructure past mathematics experiences." (Trent, 1985: 3).

intervention techniques: "procedures directed toward the long range goal of encouraging females to continue in the study of mathematics" (Pedersen, Bleyer, and Elmore, 1985: 47).

learned helpless: "a debilitating response resulting from failure on mathematical word problems" (Kloosterman, 1985: 3).

locus of control: "whether an individual's achievements are determined by forces within the person (ability or effort) or are seen as being caused by forces external to the person (task difficulty and luck)" (Covington and Beery: 67).

logo: "a computer language suitable for use by children with the power of professional programming and an emphasis on color graphics and simplicity" (Bitter and Watson: 137).

MARS: Math Anxiety Rating Scale (Richardson and Suinn, 1972: 551).

mastery orientation: when students "feel that they can succeed and thus try harder rather than give up when difficult tasks arise" (Kloosterman, 1985: 4).

mathematical self-concept: "a positive or negative belief in one's ability to learn and use mathematics" (Fennema, 1974: 186).

mathematics anxiety: "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematics problems" (Richardson and Suinn, 1972: 551).

Performance Following Failure (PFF): "a student's mastery orientation/learned helplessness as measured by his or her reaction to failure (Kloosterman, 1985: 5).

role model: "the behavior patterns or functions expected of or carried out by an individual in a given societal context" (Good: 502).

SAT: Scholastic Aptitude Test - "a test developed by the Education Testing Service for College Entrance Examination Boards to be used for college admission decisions and college counselling" (Dejnozka and Kapel: 456).

self-appraisal: "a student's evaluation and understanding of his/her interests, aptitudes, and abilities" (Good: 524).

self-efficacy: "a person's beliefs concerning his/her ability to successfully perform a given task or behavior" (Hackett and Betz, 1982: 3).

self-instruction: "a training procedure designed to influence the nature of the individual's internal dialogue to increase self-control" (Genshaft, 1982: 33).

self-schema: "the existence of networks of association used by the individual to organize and process self-relevant information" (Lips, 1984: 4).

significant others: "parents, teachers, or peers" (Pedersen, Bleyer, and Elmore, 1985: 47).

spatial visualization: "the many skills involved in maintaining spatial orientation and manipulating objects in the mind" (Skolnick, Langbort, and Day: 28).

STABS: Suinn Test Anxiety Behavior Scale (Kostka, 1986: 531).

Fennema, Elizabeth, and Thomas P. Carpenter. "Sex-related Differences in Mathematics: Results from National Assessment." Mathematics Teacher 74 (1981): 554-559.

This paper reported the sex-related differences found in a national mathematics assessment concerning courses and achievement in specific content areas. There was equal enrollment in high school mathematics courses for males and females at the beginning of the mathematics sequence. By the twelfth grade, the data suggested males enrolled in more advanced mathematics courses than females. At ages nine and 13, there was no apparent sex-related differences in mathematics achievement. However, at age 17, females did not achieve at the same level in mathematics as males even when course background was considered. Also, the size of the achievement difference increased in relation to the amount of mathematics taken.

Giese, Elizabeth. "FEER Math Study Report." Report. 1982.

This study examined the mathematics participation of students from 113 school districts in Michigan during the 1981-1982 school year. The data showed a precipitous drop occurred in mathematics enrollment of over 50 percent after students had completed beginning Algebra, usually in the ninth grade. It was found that by the twelfth grade only 45 percent of the boys and 36 percent of the girls were taking mathematics, and not all of these students were in courses considered advanced mathematics. In particular, statistics for Trigonometry and Calculus courses showed proportions of 44/56 and 37/63 for female to male course enrollment, respectively. However, the total high school enrollment showed a proportion of 49 girls to 51 boys.

Sells, Lucy W. "High School Math as the Critical Filter in the Job Market." Report. March 1973.

This paper reported the results of two studies. The first study investigated the sex differences in high school mathematics of 81 college applicants chosen at random. Of the 42 males, 57 percent took four years of high school mathematics compared to only eight percent of the 39 girls. At Berkley, a four year math sequence was required for admission to prerequisite classes required for majoring in every field except the fields of humanities, social sciences, education, and social welfare. The second study summarized responses on a questionnaire related to attitudes toward mathematics for 34 females and four males in a social science class. Strong and statistically significant relationships between social support from teachers, parents, and peers and advanced high school mathematics coursework, and between social support and mathematics performance were found.

FACTORS INFLUENCING PARTICIPATION OF FEMALES IN MATHEMATICS

Sherman, Julia. "Girls Talk About Mathematics and Their Future: A Partial Replication." Psychology of Women Quarterly 7 (1983b): 338-342.

This study attempted to replicate two earlier studies by the author in 1982. It used the same method to collect data from 63 eleventh grade girls. The following results were consistent with previous findings: girls enrolled in more mathematics courses had more favorable mathematics attitudes, came from more favored environments, were closer to their families, and were more influenced by parents. Also, the Attitude toward Success in Mathematics became more positive regardless of the number of mathematics classes taken. The data indicated that most of the girls experienced conflict between sex role and academic achievement.

Meece, Judith L. "Sex Differences in Achievement-Related Affect." Report. March 1982.

The role of affect in mathematics course enrollment decisions and mathematics achievement was investigated for 250 junior and senior high school students. While students reported generally positive attitudes towards mathematics, females reported a statistically significant higher level of mathematics anxiety. There was a tendency, although not significant, for males to have higher self-estimates of mathematical ability than females. Males, also, perceived mathematics as more valuable and useful. The factor having the strongest influence on mathematics anxiety was students' self-ratings of mathematics ability. Mathematics course enrollment intentions were influenced most by self-estimates of mathematics ability and the perceived value of mathematics.

Parsons, Jacquelynne Eccles. "Sex stereotyping Versus Perceived Value as the Mediator of Sex Differentiated Math Participation." Report. 1981.

This study evaluated both sex-typed personality characteristics and the effects of stereotyping mathematics as a male domain on mathematics attitudes and course enrollment plans. Neither students' sex role identities nor the degree of stereotyping of mathematics as masculine had any significant influence on students' attitudes toward mathematics. There was no significant relationship between sex-typing mathematics as masculine and female achievement. For males and females, it was found that positive attitudes towards mathematics were associated with having androgynous interests, rather than sex-typed interests. Females were found to rate mathematics less useful, and this factor was the best predictor of course enrollment plans. Females' estimates of the value of mathematics were significantly and positively related to their stereotypes of math as masculine, to their career plans, and to their parents' beliefs regarding the importance of mathematics and the difficulty of math.

Perl, Teri Hoch. "Discriminating Factors and Sex Differences in Electing Mathematics." Journal for Research in Mathematics Education 13 (1982): 66-74.

This paper reported an analysis of the data from the National Longitudinal Study of Mathematics Achievement to identify sex-related differences in factors believed to influence students decisions to study mathematics. The percentage of female electors (enrolled in advanced math courses) was significantly less than that for males. For both sexes, the ability and achievement factor was significant in discriminating between electors and nonelectors. However, sex differences in ability and achievement were not considered great enough to explain the differences in electing patterns. The second most important discriminating factor between electors and nonelectors was the positive attitudes factor. The data suggested that attitudes were important in explaining the disparity in electing patterns. Girls perceived math as less useful than did boys and took less advanced mathematics coursework. Confidence and mathematics anxiety could not be used to distinguish between electors and nonelectors for males or for females.

Sherman, Julia A. "Mathematics the Critical Filter: A Look at Some Residues." Psychology of Women Quarterly 6 (1982b): 428-444.

This study examined the attitudes of three cognitively equated groups of girls regarding the gender appropriateness of mathematics study. The groups were determined by the number of years of college-track mathematics each girl had taken. Girls with three or four years of mathematics planned to take further education than girls with less years of mathematics. They, also, had more ambitious and definite career plans for the future. Girls with fours years of mathematics had significantly more pleasant first experiences with mathematics and fewer negative experiences with teachers. However, they experienced more conflict between sex-role and achievement than the other girls. This study showed little evidence for parental modeling in regard to career plans.

Blackman, Sherry. "The Masculinity-Femininity of Women Who Study College Mathematics." Sex Roles 15 (1986): 33-41.

This study contrasted women who enrolled in higher level college mathematics courses with those who did not on their masculine-feminine personality traits, attitudes, and role behaviors. The subjects were 179 female undergraduates selected from the dean's list. The data indicated that the math group differed from the non-math group in regard to background information and vocational interests. However, there were no significant differences between the groups in personality traits and attitudes.

Sherman, Julia. "Continuing in Mathematics: A Longitudinal Study of the Attitudes of High School Girls." Psychology of Women Quarterly 7 (1982a): 132-140.

This study investigated the longitudinal changes in girls' attitudes toward mathematics over the high school years and their causal affect on girls'enrollment in mathematics classes. Eighty-four girls of similar intellect were given the Fennema-Sherman Mathematics Attitudes Scales in ninth grade and then again in twelfth grade. A comparison of the results showed a significant relationship between four attitudes (Usefulness of Math, Confidence in learning Math, Teacher Scale and Effectance Motivation in Math) and the continuation of the study of mathematics. As a group, the girls' attitudes were stable from grade nine to grade 12, except the Attitude toward Success in Math became significantly more positive.

Sherman, Julia. "Factors Predicting Girls' and Boys' Enrollment in College Preparatory Mathematics." Psychology of Women Quarterly 7 (1983a): 272-281.

The purpose of the study was to identify the factors that discriminate groups differing in actual mathematics enrollment behavior. As eighth graders, 337 students were given a battery of tests that included math achievement, vocabulary, spatial visualization, and a simplified version of the Fennema-Sherman Mathematics Attitudes Scales. Then as juniors in high school, the students' school records were examined for number of college prep mathematics courses taken. For females, the most important discriminators were, in order: vocabulary, Confidence in Learning Mathematics, Attitude toward Success in Math, Effectance Motivation in Math, Mathematics Concepts, Spatial Visualization, and Usefulness of Math. For males, the most important discriminators were, in order: Confidence in Learning Mathematics, vocabulary, perceived Attitude of Father toward One as a Learner of Mathematics, and Mathematics Concepts.

Sherman, Julia, and Elizabeth Fennema. "The Study of Mathematics by High School Girls and Boys: Related Variables." American Educational Research Journal 17 (1977): 159-168.

This study examined the relationships between cognitive and affective variables and the election of additional mathematics courses for males and females. Significantly more males than females planned to continue their study of mathematics, especially from the lower half of their class. All eight affective variables measured by the Fennema-Sherman Mathematics Attitude Scales differentiated between those students intending or not intending to enroll in more mathematics. However, few sex-related differences in attitudinal variables were found when mathematics achievement and intent to take another math class were controlled. The two significant sex-related differences influencing males and females, respectively, were Math as a Male Domain and Effectance Motivation in Mathematics.

Bleyer, Dorothy, Katherine Pedersen, and Patricia Elmore. "Mathematics: A Critical Filter for Career Choices." Journal of Career Education 8 (1981): 46-56.

This paper reported the results of two studies conducted at Southern Illinois University. Both studies were assessments of sex differences in math attitudes and their effect upon achievement. The first study used post secondary students in a state university, a technical institute, and a community college. The sample revealed a disproportionate number of males in the technologies area. Also, a significantly higher proportion of the females held negative mathematics attitudes than did males. Results from the attitude scales showed that females exhibited more math anxiety and math avoidance. Males, on the other hand, believed mathematics to be more useful. The second study involved 719 junior high students surveyed for math attitudes, spatial abilities, career interests, and intended mathematics coursework. No significant sex differences in spatial abilities or math achievement were found. However, there were significant differences in career choices and the math as a male domain attitude. A significant relationship for females at the sophomore level was found between math achievement and the intent to pursue mathematics.

Pedro, Joan Daniels, et al. "Election of High School Mathematics by Females and Males: Attributions and Attitudes." American Educational Research Journal 18 (1981): 207-218.

This study investigated possible attributions and attitudes that might explain the variance in female and male mathematics enrollment. A battery of tests and inventories were administered to collect data on mathematics achievement, mathematics plans, four attitudinal variables and eight attributional variables. When achievement was controlled, only a few of these variables appeared to explain high school mathematics enrollment. Usefulness had the strongest relationship with the mathematics plans of both sexes. A high correlation was, also, found between the failure-ability attribution and anxiety for female students. The female students, in this study, reported more mathematics anxiety and planned to enroll in fewer high school mathematics classes.

Shanklin, Garth R. "Escape from Mathematics Anxiety as a Factor in Major Choice." Report. 1978.

This study investigated the relationship between mathematics anxiety and the academic majors chosen by new freshmen prior to enrollment and class attendance and any differences in mathematics anxiety by sex. An inverse relationship was found between mathematics anxiety and the mathematics content of majors was found. Students in higher mathematics content majors had significanty lower mathematics anxiety than those in lower mathematics content areas. Also, women had significantly more mathematics anxiety than males.

Lips, Hilary M. "Math/Science Self-Schemas and Curriculum Choices among University Women." Report. August 1984.

This study examined the relationship between self-schemas for math/science ability among university women and the behavior of enrolling in courses with math and science content. Self-schemas were clearly related to course selections. The reason frequently given for avoidance of math and science courses was a lack of interest, not a lack of ability.

Lips, Hilary M., et al. "Self-Schema Theory and Gender-Related Behaviors: Research on Some Correlates of University Women's Participation in Mathematics, Science, and Athletic Activities." Report. 1985.

This study investigated some cognitive correlates of females in the areas of avoidance of math and science, and non-participation in athletics. It was found math/science self-schemas were clearly related to course selection. Most females who were classified as positive math/science schematics were taking courses in math and science; their reason for taking these courses was an interest in math and science. The negative schematics gave basically two reasons for not taking math and science courses: a lack of interest and a lack of background. Positive schematics, who were not taking math and science courses, stated that these courses were not relevant or required. The study, also, demonstrated that self-appraised ability on the math/science dimension is related to actual performance and career goals.

Hackett, Gail. "Mathematics Self-Efficacy and the Consideration of Math-Related Majors: a Preliminary Path Model." Report. August 1981.

This study investigated the usefulness of the concept of mathematics self-efficacy in the prediction of selecting a math-related major. A series of inventories and questionnaires were completed by 117 undergraduate students. It was found that gender and years of high school mathematics were adequate predictors of mathematics achievement, which indirectly influenced mathematics self-efficacy. Furthermore, the results indicated that math-related college major choices were predicted by gender, years of high school mathematics, math anxiety, and math self-efficacy. A path model based on self-efficacy theory, involving the interrelationships of these factors, was developed.

Hackett, Gail, and Nancy E. Betz. "Mathematics Self-Efficacy Expectations, Math Performance, and the Consideration of Math-Related Majors." Report. March 1982.

The researchers, in this study, developed an internally consistent measure of mathematics self-efficacy expectations to examine the relationship between mathematics self-efficacy expectations and the selection of math-related majors or science-based majors. Data regarding sex differences showed that college males reported significantly stronger mathematics self-efficacy expectations than did college females especially in the area of math-related courses. In particular, males scores indicated lower math anxiety, greater confidence in ability to learn mathematics, and greater tendency to view mathematics as useful than did females' scores. However, females obtained significantly higher scores on the Math as a Male Domain Scale.

DeBoer, George E. "A Study of Gender Effects in the Science and Mathematics Course-Taking Behavior of a Group of Students who Graduated from College in the Late 1970's." Journal of Research in Science Teaching 21 (1984): 95-105.

The purpose of this study was to identify how males and females differ in science and mathematics achievement and participation between high school and college. Student transcripts of 269 men and 239 women were used to collect the data. In mathematics, the participation level in college dropped off considerably from that in high school for both men and women. While men took more mathematics than women in high school and college, when the performance was controlled for ability and number of courses taken, women still achieved higher GPA's. SAT math scores and the grades in high school math courses were significantly related to the number of mathematics courses taken in college for women, but not for men. Achievement in high school mathematics and SAT scores were predictors of achievement in college for men and women.

Thomas, Gail E. "Cultivating the Interest of Women and Minorities in High School Mathematics and Science." Science Education 70 (1986): 31-43.

The purpose of this study was to identify the factors associated with students' interest in mathematics and science and to determine if there were differences based on sex or race. The following correlates and variables were included in this study: academic performance, adult role models, encouragement from significant others, teacher praise, childhood hobbies, career aspirations, and high school mathematics and science club participation. The results indicate that there is a strong relationship between students' interest in high school mathematics and three of the variables surveyed: high school academic performance, encouragement from significant others, and participation in high school mathematics clubs. However, high school grades and encouragement to major in mathematics influenced females more than males. Black respondents' interest in mathematics was more influenced by high school math club participation than white respondents.

Stallings, Jane, and Anne Robertson. "Factors Influencing Women's Decisions to Enroll in Advanced Mathematics Courses." Report. May 1979.

This study attempted to identify the factors related to high school women's decisions to enroll in advanced mathematics courses. A battery of tests was completed by 489 students in 22 geometry classes of 11 schools. The results indicated that the most important factors influencing the decision to continue the study of mathematics were parents' support and encouragement, positive experiences in mathematics classes, spatial ability on mathematics achievement tests, and career plans. Also, females in active instructional classrooms were more likely to enroll in advanced mathematics coursework.

Visser, Delene. "Sex Differences in Mathematics Achievement and Participation." Report. April 1986.

This study identified the factors affecting the mathematics participation and achievements in adolescents. Subjects were 1,605 Afrikaan speaking seventh and ninth grade students and 80 percent of their parents. More males than females took mathematics courses and made plans to continue studying mathematics. No differences in overall mathematics achievement were found in seventh, ninth, or twelfth grade males and females. While ninth grade males were significantly more positive toward mathematics than females, this was not true of males in seventh grade, except with respect to the usefulness of math. Both fathers and sons stereotyped mathematics as a male domain. Attitudinal and parental variables correlated substantially with mathematics achievement of ninth grade females. The intended participation in mathematics by ninth grade females was predicted by social, affective, and attitudinal factors, with parental encouragement being a major influence.

Pedersen, Katherine, Patricia Elmore, and Dorothy Bleyer. "Affective and Cognitive Mathematics-Related Variables: A Longitudinal Study." Report. September 1985.

The purpose of this study was to investigate the relationship between cognitive and affective mathematics related variables and the continuation in the mathematics study sequence. The subjects were 196 females and 219 males who participated in the study in grade eight and, again, in grade 12. There was no significant overall difference between the participation rate of males and of females in the mathematics study sequence. However, the proportion of males to females in Trigonometry was 31/20. For females, significant correlations were found between the continued study of mathematics and three attitudes: confidence in learning mathematics, perceived attitude of father, and perception of mathematics as a male domain. A positive correlation was found between a math- or science-related career interest and advanced mathematics course enrollment for both sexes. Attitudes towards mathematics became significantly more negative from grade eight to grade 12.

Armstrong, Jane M., and Richard A. Price. "Correlates and Predictors of Women's Mathematics Participation." Journal for Research in Mathematics Education 13 (1982): 99-109.

This study attempted to identify the most important factors affecting women's participation in mathematics by surveying 1,788 high school seniors. The overall pattern of correlations indicated that many of the factors were the same for both males and females. The factors that correlated with participation were career and educational plans, perceived usefulness of mathematics, confidence in and enjoyment of mathematics, and the active approval and encouragement of parents, teachers, counselors, and to some degree peers. However, there were differences between the sexes and predictors of participation in mathematics. For females, teacher encouragement and stereotyping played an important role in predicting participation, and influences of parents and counselors were better predictors for males. Father's educational expectations was the only factor that predicted participation for both groups.

McNamara, Patricia P., and Rita A. Scherrel. "College Women Pursuing Careers in Science, Mathematics, and Engineering in the 1970's." Report. May 1982.

The characteristics of about 7,000 females in college during the 1970's with an interest in science, mathematics, engineering were examined in this study. The results indicated that interests in science and mathematics developed in elementary and secondary school and was reinforced by academic success and outstanding teachers. Also, fewer females than males expressed an interest in science-related careers. Among the students interested in science and mathematics, the females showed less confidence than the males and switched to non-science majors more often. Females who successfully earned undergraduate degrees in science, mathematics, and engineering were exceptionally good students with strong high school preparation in science and mathematics. Support and encouragement of high school teachers and college faculty were important factors relating to females' achievement and persistence in scientific and technical majors.

Becker, Joanne Rossi. "Differential Treatment of Females and Males in Mathematics Classes." Journal for Research in Mathematics Education 12 (1981): 40-53.

This study examined the possibility of differential treatment of the sexes in high school mathematics classes and tried to determine if such treatment negatively affected the continued study of mathematics by females. Student-teacher interactions were observed for ten geometry teachers and their classes. There was a consistent pattern for more teacher-initiated contacts with males in the following areas: response opportunities, open questioning, cognitive questions, sustenance and persistence, praise and criticism, encouragement, individual help, and conversation. A tendency was observed for female students to be quieter and less active in the class than male students. This behavior had increased by the end of the study.

Fennema, Elizabeth, and Laurie H. Reyes. "Teacher/Peer Influences on Sex Differences in Mathematics Confidence." Report. October 1981.

This study examined the development of sex-related differences in teacher-pupil interactions and the influence of confidence in learning mathematics on classroom participation. The subjects were 80 middle school students with approximately equal numbers of males and females included. It was found that teachers initiated more interactions with boys than girls by asking more questions of boys and disciplining them more often. Boys, also, initiated more interactions with teachers than did girls. When mathematics confidence was considered, the high confidence boys participated in more teacher interactions than other students, and high confidence girls participated in fewer teacher interactions than other students.

McDermott, Marilyn. "The Impact of Classroom Interaction Patterns on Students' Achievement-Related Beliefs and Behavior." Report. April 1983.

This project attempted to determine if teacher expectations influenced their interaction with students, and what possible effect this had on students. The high expectancy students received higher grades in math. Significant differences in classroom interactions were found between high and low expectancy students and between males and females. While high expectancy students received more positive feedback, low expectancy students received more criticism. Females received a higher percent of the work praise, but males received more criticism, sustaining questions, and feedback. Differences in classroom interactions between sex and teacher expectations were found. High females received less teacher attention than low females, but high males received an equal amount or more than low males. There was no clear relationship found between classroom interactions and males' attitudes or performance. However, greater teacher interaction for high and low females was positively correlated with their value of mathematics and with their intent to take more mathematics.

Casserly, Patricia L., and Donald Rock. "Factors Related to Young Women's Persistence and Achievement in Advanced Placement Mathematics." Report. October 1980.

This study was designed to study factors within secondary schools that tend to affect females' enrollment, persistence, and achievement in advanced mathematics courses. It was found that the role of parents was most significant in developing early positive attitudes towards women's roles for both males and females. For females, the presence of friends in advanced mathematics classes positively affected grades, mathematics self-concept, the decision to take mathematics courses, and the level of educational aspirations. Performance for all students in advanced mathematics classes was significantly related to encouragement from math teachers. It was, also, found that females made decisions about math-related careers based on previous grades and encouragement of school personnel outside of mathematics.

FACTORS INFLUENCING ACHIEVEMENT OF FEMALES IN MATHEMATICS

Armstrong, Jane M. "Achievement and Participation of Women in Mathematics: Results of Two National Surveys." Journal for Research in Mathematics Education 12 (1981): 356-372.

This study used the results of two national surveys on mathematics achievement and participation by males and females to determine if sex differences in achievement persist when coursework is controlled. The two data sources were the Women in Mathematics Project and the National Assessment of Educational Progress. It was found that 13 year old females were significantly better at computation and spatial visualization than males of the same age, but the problem solving skills of males and females were nearly equal. By twelfth grade, there was a large statistical difference favoring males on problem solving measures, and no statistical difference between the sexes in computation and in spatial visualization. While both studies showed similar rates of participation for males and females in the basic mathematics courses, there were significant differences in mathematics enrollment favoring males at the higher level courses. When the level of participation was controlled, the statistically significant sex-related differences on the algebra achievement tests disappeared.

deWolf, Virginia A. "High School Mathematics Preparation and Sex Differences in Quantitative Abilities." Psychology of Women Quarterly 5 (1981): 555-567.

This study tested the hypothesis that when students were grouped according to their pattern of mathematical coursework, sex differences in quantitative and spatial abilties would be eliminated. The subjects were 2,093 high school students who had completed the Washington Pre-College Testing Program (WPC) during the eleventh grade. The results showed that males took significantly more college preparatory mathematics and physics courses and scored higher on all six WPC tests. Females had higher overall mathematics GPA's than males. However, sex differences disappeared on two of the four quantitative tests and on the spatial ability test when coursework preparation was statistically controlled.

Moss, Jillian D. "Towards Equality: Progress by Girls in Mathematics in Australian Secondary Schools." Report. February 1982.

This paper reported the results of two investigations carried out by the Australian Council for Educational Research in 1964 and in 1978. No significant gains were found in the average level of achievement in mathematics learning of girls relative to boys over the 14 year period between studies. However, there was a significant and positive change in the degree of participation of girls in mathematics courses over the same period of years. After a statistical allowance was made for hours of mathematics learning, there was no evidence for sex differences in mathematics achievement at the end of secondary school level.

Fallas, Aaron M., and Karl L. Alexander. "Sex Differences in Quantitative SAT Performance: New Evidence on the Differential Coursework Hypothesis." American Educational Research Journal 20 (1983): 165-182.

This study tested the hypothesis that differences in high school quantitative course enrollment account for differences in SAT-M performance between males and females. The data used in the study are background variables, ninth grade quantitative test scores (School and College Ability Test, SCATQ), quantitative course enrollment, GPA for quantitative courses, and twelfth grade SAT-M scores. There were no significant differences in the background variables of father's education, mother's education, race, and ninth grade SCATQ performance between males and females. However, there is a significant sex difference in twelfth grade SAT-M performance favoring males. It was, also, found that females take fewer advanced mathematics and science courses, but attain higher GPA's in the courses they do take. When sex differences in high school quantitative coursework were controlled, the male-female gap in SAT-M scores lessened considerably (about 60 percent).

Dees, Roberta L. "Sex Differences in Geometry Achievement." Report. March 1982.

This paper reported the results of a nationwide study to investigate possible sex differences in entering knowledge of geometry or in geometry achievement at the end of a course. The subjects included 1,392 males and 1,307 females in 99 classes, in grades seven through 12. Results showed that males had significantly more content knowledge upon entering the geometry courses than females. When scores were adjusted for this entering knowledge, no consistent patterns of sex differences in geometry achievement were found for writing geometry proofs or for learning geometry content.

Senk, Sharon, and Zalman Usiskin. "Geometry Proof Writing: A New View of Sex Differences in Mathematics Ability." American Journal of Education 91 (1983): 187-201.

This study tested for sex differences in performance on writing geometry proofs considered to be a high-level cognitive skill involving some spatial ability. A total of 1,364 students in 74 classes from 11 high schools in five states were pretested to determine entering knowledge of geometry terminology and facts and were posttested with one of three forms of a proof test and a standardized geometry achievement test (Comprehensive Assessment Program, CAP). Females scored significantly lower than males on the pretest. On the proof test, males scored higher than females, but never significantly. When entering geometry knowledge was statistically controlled, the results favored females, but again not significantly. Results on the CAP test showed that males' scores were significantly higher than females' scores. However, when geometry experience was controlled, the CAP scores were nearly identical. When three subgroups of high-achieving students were examined, the results for the proof test did not show any significant differences.

Hendel, Darwin D. "Experiential and Affective Correlates of Math Anxiety in Adult Women." Psychology of Women Quarterly 5 (1980): 219-230.

The purpose of this study was to determine background characteristics of participants in a mathematics anxiety program, to find a relationship between mathematics anxiety and other anxiety scales, to discover if background variables can be used to predict mathematics anxiety, and to determine if mathematics anxiety can be used to predict arithmetic performance. The subjects, 69 female participants in a math anxiety progam at a large midwestern university, were given five anxiety scales, an arithmetic test, and a background questionnaire. The results showed a high negative correlation between self-estimated mathematics ability and mathematics anxiety. Mathematics anxiety for these participants was highly correlated to the other measures of academic anxiety. However, the highest correlation was found between math anxiety and test anxiety. Both mathematics anxiety and semesters of high school mathematics were important variables when predicting arithmetic performance.

Austin-Martin, George, Linda Waddell, and Marylor Butler Kincaid. "Correlates of Math Anxiety in Female College Freshman." Report. October 1980.

This study examined the correlates of math anxiety in 344 female college freshmen at a private women's liberal arts college in the Midwest. The results showed that math anxiety was negatively correlated with mathematics achievement. Students' attitudes toward mathematics were found to be important correlates of math anxiety. Math anxiety was significantly related to scores on the Confidence in Learning Mathematics Scale and the Usefulness of Mathematics Scales. However, it was found the math anxiety was negatively correlated with scores on the Attitude toward Success in Mathematics Scale and Mathematics as a Male Domain Scale. There was, also, a significant correlation between the number of mathematics courses taken and math anxiety. No relationship between math anxiety and parents' occupation was found.

Kincaid, Marylou Butler, and George Austin-Martin. "Relationships Between Math Attitudes and Achievement, Parents' Occupation, and Math Anxiety in Female College Freshmen." Report. January 1981.

This study investigated the relationship of math anxiety to mathematics achievement, math attitudes, and parents' occupation of 344 female college freshmen. High math anxiety students had much lower mathematics achievement scores than low anxiety students. In fact, achievement was significantly and positively related to math anxiety for low anxiety students. The results showed significant differences between high and low math-anxious students and their attitudes towards mathematics. Low anxiety students had significantly more confidence in their math ability than high anxiety students. Math as a male domain and attitude toward success were significantly and positively related to math anxiety for low anxiety students, but significantly and negatively related to math anxiety for high anxiety students. There was no significant relationship found between students' math anxiety and parents' occupations.

Butler, Marylou, and George Austin-Martin. "High Math Anxious Female College Freshman: What Do They Have in Common?" Report. August 1981.

The relationship of math anxiety to mathematics attitudes and mathematics achievement for 62 high math anxious female college freshmen was studied. A battery of tests which included an achievement test and the Fennema-Sherman Mathematics Attitudes Inventory were given to females at a women's liberal arts college in the Midwest. They were divided into three anxiety-level groups: high, very high, and extremely high. The students in the three groups had achievement levels less than eighth grade and had taken less than three mathematics courses in high school. The extremely high math anxious group had less confidence in themselves as learner of mathematics, but valued success in mathematics more than the others.

Wooley, Daniel. "The Effects of Sex and Anxiety on Mathematics Performance." Report. 1982.

This study examined the effects of sex, anxiety, and item difficulty on performance as measured by a mathematics test. Sixty junior high school students, 30 males and 30 females, were randomly assigned to one of two anxiety groups. Anxiety was defined as a result of directions given to the two anxiety groups. The results showed that anxiety had a significant effect on performance on the low difficulty problems. However, the results were not significant for the effects of anxiety on the high difficulty problems. No significant differences in mathematics performance or mathematics anxiety between males and females were found.

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors." American Educational Research Journal 14 (1977): 51-71.

This study investigated sex-related differences in mathematics achievement when mathematics background was controlled and the relationships of spatial visualization, mathematics attitudes, and math-related activities to mathematics achievement. A battery of tests which included the Fennema-Sherman Mathematics Attitudes Scales were administered to 589 female and 644 male ninth through twelfth grade students selected by mathematics background. Males tended to score higher on spatial visualization and mathematics achievement but the differences were significant at only two of the four schools in the study. It was, also, found that males engaged in more math-related activities in and out of school. Significant comparisons were found favoring males in the areas of confidence in learning mathematics, mathematics as a male domain, parents as more positive toward them as learners of mathematics, and mathematics as more useful. However, a factor analysis indicated that attitudes were more important to females' learning of mathematics than to males' mathematics learning.

Pedersen, Katherine, Dorothy R. Bleyer, and Patricia B. Elmore. "Attitudes and Career Interests of Junior High School Mathematics Students: Implications for the Classroom." Arithemetic Teacher 32 (1985): 45-49.

The study investigated attitudes toward mathematics, spatial visualization, career interests, and academic plans relative to mathematics achievement for junior high school students. The study included 1,937 seventh and eighth grade students. The statistics revealed an overall decrease in females' scores concerning positive attitudes toward mathematics and on mathematics achievement from seventh to eighth grade. Eighth grade females had less interest in taking high school mathematics than seventh grade females or eighth grade males. The data from the study indicated that junior high school students exhibited the traditionally accepted sex-defined career interests. While males showed a significantly higher interest in science and in technology and trade, females chose careers in creative and applied arts; in social, health, and personal services; and in business communication.

Sherman, Julia. "Mathematics, Spatial Visualization, and Related Factors: Changes in Girls and Boys, Grades 8-11." Journal of Educational Psychology 72 (1980): 476-482.

The study examined sex-related differences in mathematics performance and their possible cognitive and affective factors. In grade eight, there were no significant differences between boys and girls in mathematics achievement, in spatial visualization, or in attitudes (except Math as a Male Domain). By grade 11, boys performed significantly better in mathematics, even when the mathematics background was controlled. For girls, Math as a Male Domain was found to be a significant predictor of mathematics achievement in grade 11.

Analysis of the results from the Fennema-Sherman Mathematics Attitudes Scales II showed a significant decline in girls' attitudes toward mathematics (Confidence in Learning Math, Teacher, Usefulness of Math, and Effectance Motivation in Math) from grades eight to 11. Few significant differences in boys' attitudes occurred.

Fennema, Elizabeth H., and Julia Sherman. "Sex-Related Differences in Mathematics Achievement and Related Factors: A Further Study." Journal for Research in Mathematics Education 9 (1978): 188-203.

This study examined sex-related differences in mathematics achievement, and in cognitive and affective variables related to mathematics. A battery of mathematics achievement tests and the Fennema-Sherman Mathematics Attitudes Scales were administered to 1,320 sixth through eighth grade students. Significant sex-related differences were found for only two affective variables. Males were significantly more confident of their ability to learn mathematics than were females, and males stereotyped mathematics as a male domain at higher levels than did females. No consistent sex-related differences in mathematics learning were found.

Hilton, Thomas L., and Gosta W. Berglund. "Sex Differences in Mathematics Achievement - A Longitudinal Study." Journal of Educational Research 67 (1974): 231-237.

The relationship between math-related interests and sex differences in mathematics achievement was studied. This study used longitudinal data from the Growth Study at the Educational Testing Service, begun in 1961. The Sequential Test of Educational Progress and the School and College Ability Test were used to measure the change in mathematics achievement. A background and experience questionnaire was used to determine if any patterns of sex differences in students' interests in mathematics occurred with age. At grade five, the results showed no sex differences in mathematics achievement. As grade levels increased, there were increasing differences in mathematics achievement between males and females, in favor of males. Parallel differences were found for students' interest in mathematics and for students' perception of mathematics as useful in earning a living.

Kloosterman, Peter. "Sex-Related Differences in Students' Reactions to Failure on Algebra Word Problems." Report. 1985.

This study investigated sex-related differences in performance following failure and whether students with positive Performance Following Failure scores (mastery orientation) achieved higher in mathematics than students with negative Performance Following Failure scores (learned helplessness). The subjects were 63 males and 61 females enrolled in beginning algebra. It was found that females had significantly lower PFF scores than did males. Therefore, the females subjects were more learned helpless than the males in this study. Also, females with positive PFF scores achieved significantly higher than females with negative PFF scores. In fact, PFF was found to be a significant predictor of achievement for females, but not for males.

Abel, Theodora Mead, Robert Cogburn, and Phyllis Hersh. "Women and Mathematics: Research on Aptitude vs. Achievement in Education." Report. November 1983.

This study tried to discover if spatial skills were a major prerequisite for mathematics achievement by studying the use of visual-spatial skills by 32 professional mathematicians. The Witkin Embedded Figure Test (EFT) was used to evaluate the visual spatial-ability of the subjects. No clear causal relationship was found between the subjects' ability to solve problems on the EFT and their mathematics achievement. After interviewing the subjects, no concensus was found that visual-spatial ability was useful to mathematicians.

Weiner, Neil C., and Sharon E. Robinson. "Cognitive Abilities, Personality and Gender Differences in Math Achievement of Gifted Adolescents." Report. 1983.

This study attempted to determine if mathematically gifted males and females were significantly different in cognitive abilities and personality factors. This study, also, examined whether these factors could predict mathematics achievement. The subjects were 77 males and 62 females enrolled in an accelerated mathematics summer program. Males scored significantly higher on the mathematical reasoning ability test (SAT-M) than did girls. In fact, mathematical reasoning ability was found to be the best predictor of mathematical achievement for males. However, verbal ability was the best predictor of mathematical achievement for girls. There was no significant gender differences found in spatial ability or in personality traits. Also, spatial reasoning and personality factors were not significant predictors of mathematical achievement for males or for females.

INTERVENTION PROGRAMS

Brunson, Pansy Waycaster. "A Classroom Experiment Involving Basic Mathematics and Women." Two Year College Mathematics Journal 14 (1983): 318-321.

The study compared the achievement of an all-female section of basic algebra class to the achievement of women in mixed-sex classes. First, the women in the all-female class had lower math ability (SAT) scores, but scored significantly higher achievement scores than women in the mixed-sections. Secondly, there was a lower withdrawal rate in the all-female section than in the mixed sex classes. Finally, the MARS posttest scores were significantly lower than the MARS pretest scores for both groups of women with no significant differences between the two groups on either test. Most women in the all-female class reported choosing the class because of a fear of intimidation by men, but some women chose the section for the opportunity to meet other women.

Macfarlane, Jim, and Pat Crawford. "Effects of Sex-Segregated Mathematics Classes on Student Attitudes and Achievement in Mathematics: A. Y. Jackson Secondary School, Year 1." Report. September 1985.

This study evaluated the effects of the sex-segregated classes on student attitudes and on student achievement. The results showed there were no significant changes in students' attitudes toward mathematics, although 25 percent of all students, mostly females, indicated that the classes had helped to improve their mathematics attitudes. Also, both males and females became more interested in careers which required mathematics. The results, also, showed there were no significant difference in mathematics achievement. Teachers of all-female classes and female students reported a more relaxed and open atmosphere where students were less hesitant to ask and answer questions.

Schwartz, Helga, and Sarah Papier. "A Head Start in Mathematics for Girls in Elementary School: A Pilot Study." Urban Education 19 (1985): 351-364.

This paper focussed on a pilot study in which eight weekly mathematics enrichment classes were offered to fifth and sixth grade girls in one class and to boys in a separate class. A pretest and posttest in problem solving was given to both groups. It was observed by the instructor that the girls worked cooperatively as a cohesive group. The instructor, also, stated that the girls' class could have been an hour longer with continued positive results. On the otherhand, the boys were observed to have much shorter attention spans and to lack the ability to work cooperatively. The boys' class was shortened by 15 minutes after the second week. At the end of the eight week sessions, most girls stated that they enjoyed having a math class without boys. Both groups increased their Grade Equivalent (G.E.) scores in problem solving by nearly a year by the end of class. The girls whose pretests were below the class median inproved from a mean G.E. of 3.0 to a mean G.E. of 5.1. While the boys' pretest scores below the median went from a mean G.E. of 6.0 to a mean G.E. of 6.6.

Genshaft, Judy L. "The Use of Cognitive Behavior Therapy for Reducing Math Anxiety." School Psychology Review 11 (1982): 32-34.

This paper reported the results of a program of self-instruction used with mathematics anxious women to teach them a strategy for controlling their anxious behavior. The subjects were 36 middle-class, seventh grade females with average intelligence. They had been identified as math-anxious since their math achievement was at least one year lower than their reading achievement. The females were divided into three groups: a control group, a tutoring group, and self-instruction group with tutoring. The self-instruction group was the only group to significantly improve on the computations section of the mathematical achievement test. There was no significant difference on the applications section of test; all three groups showed improvement. The attitude toward mathematics was more positive for the self-instruction group, while the other students' attitudes remained the same.

Trent, Richard M. "Hypnotherapeutic Restructuring and Systematic Desensitization as Treatment for Mathematics Anxiety." Report. April 1985.

The purpose of this study was to develop a mathematics anxiety treatment program and evaluate the program's effectiveness for lowering math anxiety, changing attitude, and improving math performance. College students were randomly assigned to one of three treatment programs: hypotherapeutic restructuring (HR), systematic desensitization, and an expectancy control group. All three groups showed significant improvement in math anxiety. However, only the HR treatment showed significant positive changes in mathematics attitudes and mathematics performance. The HR treatment program was designed to restructure the cognitive schema of mathematics anxiety victims by convincing each subject that mathematics is valuable, logical, comprehensible, and under their control.

Kostka, Marion P., and Christine K. Wilson. "Reducing Mathematics Anxiety in Nontraditional-Age Female Students." Journal of College Student Personnel 27 (1986): 530-534.

This study described the results of a program designed to help women reduce their mathematics anxiety by improving their mathematics skills and learning ways to cope with their anxiety. The participants were women 25 to 47 years old. The program consisted of 11 two-hour sessions. Each session was divided into two parts: building math skills and reducing math anxiety. The results of the pretests and posttests for the MARS, the STABS, and achievement tests showed significant positive changes. A questionnaire given at the end of the program, also, revealed that the participants were more confident in their mathematics ability.

Confrey, Jere. "SummerMath: Research into Practice." Report. April 1983.

This study evaluated a six-week SummerMath program for high school females that was designed and implemented by the author. The goal of the program was to encourage young females to continue in the study of mathematics by gaining an understanding of mathematics. No significant gains were found in arithmetic or algebra achievement. However, there were significant improvements in confidence in mathematics and in math-anxiety for most participants. No differences were found in their enjoyment of mathematics, in their attitudes toward female-role models, or in their perception of mathematics as useful. Sixty-one percent of the students indicated that they were more aware of the applicability of mathematics to various careers.

Fox, Lynn H. "Women and Mathematics: The Impact of Early Intervention Programs upon Course-Taking and Attitudes in High School." Report. 1979.

This study examined the effectiveness of two intervention programs at the John Hopkins University, in terms of increasing females' participation in mathematics. The females in the accelerated mathematics classes achieved as well as the males in these classes and indicated a commitment to advanced mathematics coursework. Females in the classes with a career awareness component and female role models had higher educational aspirations than males or females in the control group or the accelelerated mathematics classes only. The mathematically-able seventh grade females and males were found to be more alike than different with respect to attitudes and interests. However, males and females differed significantly in attitudes related to career and life style expectations for themselves and their future spouses. Less than half the females (47 percent) and 97 percent of the males expect to have a full-time career. Only 13 percent of the males and about 94 percent of the females expect their spouses to work full time.

Fennema, Elizabeth, et al. "Increasing Women's Participation in Mathematics: An Intervention Study." Journal for Research in Mathematics Education 12 (1981):3-14.

The purpose of this study was to determine if Multiplying Options and Subtracting Bias was an effective intervention program. This program was designed to change female students' and some of their significant others' beliefs about women and mathematics. One of three 30-minute video tapes was part of a two-hour workshop for each target group: students, teachers, and counselors. The variables related to mathematics were course enrollment, attitudes, knowledge of sex-related differences and attribution. There were no significant differences between the experimental and control groups or between the sexes at the beginning of the study. The posttest results of the experimental females differed significantly from the control females on knowledge, usefulness, success-ability, and mathematics course enrollment. As a group, there was no statistically significant change for teachers of either group; however, the male teachers of the experimental group increased their knowledge of sex-related differences. Counselors in the experimental group recognized more anxiety in female students.

Clarke, Valerie A. "The Impact of Computers on Mathematics Abilities and Attitudes: A Pilot Study Using Logo." Journal of Computers in Mathematics and Science Teaching 5 (1985-1986): 32-33.

This pilot study attempted to establish a relationship between children's attitudes towards mathematics and general ability before and after a school year of Logo learning experiences. At a girls' school, 43 students in grades one, three, and five were given two pretests and two posttests measuring general ability and interest in learning mathematics, science, social science, and reading. During the school year, there were two Logo learning experiences per week. At the end of the year, there were significant increases in both the general ability and attitudes toward mathematics. There were, also, increases in mean scores for attitudes toward science, social studies, and reading, but the differences were not found to be statistically significant.

Lewis, Mark A., and John B. Cooney. "Attributional and Performance Effects of Competitive and Individualistic Feedback in Computer Assisted Mathematics Instruction." Report. April 1986.

This study assessed the effects of competitive and individual feedback on students' achievement and attribution behavior within the context of computer based education. The results indicated that the treatment conditions affected the performance of males and females differently. Competitive group males exhibited a significantly higher rate of progress than females in the same group. The individual group females, also, showed a significantly greater rate of progress as compared to the competitive group females. Gender differences in academic locus of control were not found. All students in the competitive group showed a significant increase in attributions to ability for success.

Van Der Wert, Greetje. "Girls and Mathematics: the New Math Program." Report. April 1986.

In the Netherlands, there was a major mathematics curriculum change consisting of two programs, math A and math B. Math A prepared students for university studies in humanities and economics, and math B prepared students for university studies in science, technics, agriculture, and medicine. This paper described the effects of the new math program on pupils' choices of mathematics and about the effects of math A on their attitudes towards the subject. Under the new curriculum, students chose a math program significantly more often than students in the traditional program. Girls chose math A significantly more often than boys, while boys took both math A and math B more frequently than girls. There was no significant differences in attitudes between students in the new or traditional programs. However, there were some sex-related differences in attitudes. Girls perceived math as a male domain less than boys, but also perceived their abilities to be less positive than boys. Boys and girls did agree on the usefulness of mathematics.

SUMMARY

This paper examined the research concerned with increasing the participation and achievement of females in mathematics. While equal enrollment at the beginning of the high school mathematics sequence was found for females and males, by twelfth grade more males than females enrolled in advanced mathematics classes (Fennema and Carpenter, 1981). In particular, the PEEP Math study found a proportion of 37/63 for female to male enrollment in the advanced class of Calculus (Geise, 1982). While few sex-related differences in mathematics achievement were found in grade eight, males performed significantly better in mathematics than females by grade 11 (Sherman, 1980). Sells also found that eight percent of the females verses 57 percent of the males in a random sample of entering freshman at Berkley had taken four years of high school mathematics. Since a four year math sequence was required for admission to prerequisite classes required for most majors, math was called the "critical filter" (Sells, 1973).

Various attitudinal variables were found to influence the participation of females in mathematics. Girls who enrolled in more mathematics had more favorable mathematics attitudes (Sherman, 1983b). In particular, a major predictor of females' choosing more mathematics was the perceived usefulness of mathematics (Meece, 1982; Parsons, 1981; Perl, 1982). Females with more definite career plans

and interests enrolled in more advanced mathematics courses (Sherman, 1982b; Blackman, 1986). Sherman found a significant relationship between continuation of the study of mathematics and usefulness of mathematics, but also confidence in learning mathematics, and effectance motivation in mathematics were significant factors (1982a and 1983a). The results of another study also indicated that effectance motivation was a significant factor influencing the election of additional mathematics classes (Sherman and Fennema, 1977). Females were found to exhibit more mathematics anxiety than males while enrolling in fewer mathematics and math-related courses (Bleyer, Pedersen, and Elmore, 1981; Fedro, 1981; Shanklin, 1978). Two studies conducted by Lips found that mathematics self-schemas and an interest in mathematics were clearly related to mathematics course selection (Lips, 1984; Lips et al., 1985). Math-related college major choices were found to be predicted by mathematics self-efficacy, a construct related to self-schemas (Hackett, 1981; Hackett and Betz, 1982). Furthermore, a significant relationship was found between high school mathematics grades and an interest in mathematics courses (DeBoer, 1984; Thomas, 1986).

Another important area of research included the influence of "significant others" on the participation of females in mathematics. Parental encouragement and support were found to be a major factor influencing females'

decisions to continue the study of mathematics (Stallings and Robertson, 1979; Visser, 1986) with the perceived attitude of the father as very important (Pedersen, Elmore, and Bleyer, 1985). The encouragement and support of teachers were also found to be important when predicting the participation of females in mathematics (Armstrong and Price, 1982; McNamara and Scherrel, 1982). Two studies looked at teacher interactions in mathematics classes and found that there were definite sex differences with males getting most of the teacher-initiated contacts (Becker, 1981; Fennema and Reyes, 1981; McDermott, 1983). McDermott found a positive correlation between teacher interaction for females and their intent to take more mathematics and also their value of mathematics (1983). The presence of friends in mathematics classes was found to positively affect females' decisions to take mathematics courses (Casserly, 1980).

Another major focus of the research literature concerning females and mathematics is factors influencing achievement. When mathematics coursework was controlled, sex differences in mathematics achievement disappeared or lessened considerably (Armstrong, 1981; deWolf, 1981; Moss, 1982; Pallas and Alexander, 1983). The results of two studies showed that when entering geometry knowledge was statistically controlled, sex differences in geometry

achievement did not favor males (Dees, 1982; Senk and Usiskin, 1983).

Research revealed a complex relationship between mathematics anxiety and mathematics achievement. In a study conducted by Hendel, mathematics anxiety was found to be an important factor when predicting arithmetic performance (1980). However, in three studies using the same sample of female college freshmen, different relationships were found between mathematics anxiety and mathematics achievement. The results of the first study found mathematics anxiety was negatively correlated with mathematics achievement (Austin-Martin, Waddell, Kincaid, 1980). However, the second study found a positive relationship between achievement and mathematics anxiety for low anxiety females (Kincaid and Austin-Martin, 1981). The third study found that high anxiety females had achievement levels less than eighth grade (Butler and Austin-Martin, 1981). Another study found anxiety to have a significant effect on performance on low difficulty test questions (Wooley, 1982).

Attitudes toward mathematics also influenced the achievement of females in mathematics. Fennema and Sherman found that attitudes were important to females' learning of mathematics (1977). A decline in females' attitudes toward mathematics was reported from seventh to eighth grade (Pedersen, Bleyer, and Elmore, 1985) and from eighth grade to eleventh grade (Sherman, 1980). Although no sex-related

differences in mathematics learning were found for students in sixth through eighth grade, the females were significantly less confident of their mathematics ability than males (Fennema and Sherman, 1978). As grade levels increased, a decrease in females' mathematics achievement, interest in mathematics and perception of mathematics as useful was reported (Hilton and Berglund, 1974). The Performance Following Failure construct was found to be a significant predictor of achievement for females (Hoosterman, 1985).

Spatial ability and its relationship to mathematics achievement was examined in two studies. Spatial ability was not found to be a significant predictor of mathematics achievement (Abel, Cogburn, and Hersh, 1983; Weiner and Robinson, 1983). In fact, when 32 professional mathematicians were interviewed, no concensus could be found that spatial ability was useful to mathematicians (Able, Cogburn, and Hersh, 1983).

Research studies evaluated various intervention methods designed to stimulate females to study and learn more mathematics. Three studies evaluated the effects of sex-segregated classes on student achievement. One study found that students in an all-female basic college algebra class had significantly higher achievement scores than females in the mixed-sections (Brunson, 1983). In the other two studies, a more relaxed and open atmosphere for learning

was reported in the all-female classes (Macfarlane and Crawford, 1985; Schwartz and Papier, 1985).

Another intervention method used by three studies was the reduction of mathematics anxiety. A program that used self-instruction to reduce mathematics anxiety reported significant improvements on a mathematical achievement test and more positive attitudes toward mathematics (Genshaft, 1982). Another study evaluated two different treatment programs: hypotherapeutic restructuring (HR) and systematic desensitization. While both treatments showed significant improvement in mathematics anxiety, only the HR treatment showed significant positive changes in mathematics attitudes and mathematics performance (Trent, 1985). A third program that focussed on remediation and anxiety reduction skills showed significant improvements for mathematics achievement and attitudes (Kostka and Wilson, 1986).

Career counseling and awareness for females were the focus of some intervention programs. A study of a SummerMath program that provided career counseling showed significant improvements in confidence in ability and mathematics anxiety for most participants (Confrey, 1983). At the John Hopkins University, two intervention programs to increase females' participation in mathematics were evaluated. Both programs were accelerated mathematics classes, but one included a career awareness component with female role models. At the end of the program, females in

the latter class had higher educational aspirations than the males or females in the other class (Fox, 1979). A third study, Multiplying Options and Subtracting Bias, was designed to make females more aware of problems for women in mathematics. At the end of the program, the females in the experimental group found mathematics to be more useful and planned to enroll in more mathematics courses than the control group (Fennema et al., 1981).

There were also several miscellaneous intervention programs that reported successful results. After a year of Logo learning experiences, significant increases in both the general ability and attitudes toward mathematics were reported (Clarke, 1985-1986). When comparing the effects of competitive and individualized feedback on students' achievement within the context of computer based education, it was found that females in the individualized group showed a significantly greater rate of progress than the females in the competitive group (Lewis and Cooney, 1986). Another study examined a major curriculum change in the Netherlands where two mathematics programs were designed to prepare students for different college majors: humanities-related majors and science-related majors. Under the new curriculum, students chose a math program significantly more often than students in the traditional program (Van Der Werf, 1986).

CONCLUSIONS

Numerous researchers have identified various factors that may affect females' participation and achievement in mathematics. These factors can be summarized by the following four categories of variables: attitudes toward mathematics, especially the perceived usefulness of mathematics for educational and career goals; mathematics anxiety; positive influence of "significant others"; and females' mathematics background.

Several intervention programs designed to increase females' participation in mathematics and to improve females' mathematics achievement have been described. Aspects of these successful intervention programs included activities to increase career awareness, to increase mathematics skills, and to reduce mathematics anxiety. A few studies examined the effects of sex-segregated classes on females' attitudes toward mathematics and mathematics achievement and found improvement in mathematics achievement and classroom environments. Two studies made use of the computer in their intervention programs with positive results. Another program attracted more females to the study of mathematics by redefining an entire high school mathematics curriculum based on two different college preparatory tracks of mathematics.

RECOMMENDATIONS

Based on the findings cited in this paper, it is advised that teachers incorporate into their lesson plans and classroom environments the following recommendations:

1) Expect both males and females to be successful in their overall mathematics performance.
2) Encourage females as well as males to take mathematics in higher education.
3) Be aware that females may have higher levels of mathematics anxiety than males.
4) Use parent-teacher conferences to promote the value of mathematics for girls in many activities outside of school.
5) Be aware of sex-biased interaction patterns in the classroom that may exclude female participation.
6) Provide students information about the importance of high school mathematics for future educational and career goals.
7) Model enthusiasm and positive attitudes toward mathematics.

It is also recommended that researchers continue to investigate the possible causes of the observed sex differences in mathematics achievement and participation. Identification of and intervention into the factors causing differential achievement and participation may help to eliminate sex differences found in the study of mathematics

and help equalize the educational and career opportunites between males and females.

BIBLIOGRAPHY

Abel, Theodora Mead, Robert Cogburn, and Phyllis Hersh. "Women and Mathematics: Research on Aptitude vs. Achievement in Education." Report. November 1983. (31, 43)

Armstrong, Jane M. "Achievement and Participation of Women in Mathematics: Results of Two National Surveys." Journal for Research in Mathematics Education 12 (1981): 356-372. (3, 23, 41)

Armstrong, Jane M., and Richard A. Price. "Correlates and Predictors of Women's Mathematics Participation." Journal for Research in Mathematics Education 13 (1982): 99-109. (1, 2, 19, 41)

Austin-Martin, George, Linda Waddell, and Marylou Butler Kincaid. "Correlates of Math Anxiety in Female College Freshman." Report. October 1980. (26, 42)

Becker, Joanne Rossi. "Differential Treatment of Females and Males in Mathematics Classes." Journal for Research in Mathematics Education 12 (1981): 40-53. (1, 2, 20, 41)

Bitter, Gary G., and Nancy Ralph Watson. Apple Logo Primer. Reston: Reston - Prentice-Hall Co., 1983. (5)

Blackman, Sherry. "The Masculinity-Femininity of Women Who Study College Mathematics." Sex Roles 15 (1986): 33-41. (1, 2, 11, 40)

Bleyer, Dorothy, Katherine Pedersen, and Patricia Elmore. "Mathematics: A Critical Filter for Career Choices." Journal of Career Education 8 (1981): 46-56. (1,2,13,40)

Brunson, Pansy Waycaster. "A Classroom Experiment Involving Basic Mathematics and Women." Two Year College Mathematics Journal 14 (1983): 318-321. (33, 43)

Butler, Marylou, and George Austin-Martin. "High Anxious Female College Freshman: What Do They Have in Common?" Report. August 1981. (27, 42)

Casserly, Patricia L., and Donald Rock. "Factors Related to Young Women's Persistence and Achievement in Advanced Placement Mathematics." Report. October 1980. (22, 41)

Clarke, Valerie A. "The Impact of Computers on Mathematics Abilities and Attitudes: A Pilot Study Using Logo." Journal of Computers in Mathematics and Science Teaching 5 (1985-1986): 32-33. (37, 45)

Confrey, Jere. "SummerMath: Research into Practice." Report. April 1983. (36, 44)

Covington, Martin V. and Richard G. Beery. Self-Worth and School Learning. New York: Holt, Rinehart, and Winston, 1976. (4, 5)

DeBoer, George E. "A Study of Gender Effects in the Science and Mathematics Course-Taking Behavior of a Group of Students who Graduated from College in the Late 1970's." Journal of Research in Science Teaching 21 (1984): 95-105. (1, 2, 17, 40)

Dees, Roberta L. "Sex Differences in Geometry Achievement." Report. March 1982. (25, 42)

Dejnozka, Edward L., and David E. Kapel. American Educators' Encyclopedia. Westport: Greenwood Press, 1982. (4, 6)

deWolf, Virginia A. "High School Mathematics Preparation and Sex Differences in Quantitative Abilities." Psychology of Women Quarterly 5 (1981): 555-567. (23, 41)

Fennema, Elizabeth. "Sex Differences in Mathematics Learning." Elementary School Journal 75 (1974): 183-190. (5)

Fennema, Elizabeth, et al. "Increasing Women's Participation in Mathematics: An Intervention Study." Journal for Research in Mathematics Education 12 (1981): 3-14. (1, 2, 37, 45)

Fennema, Elizabeth, and Thomas P. Carpenter. "Sex-Related Differences in Mathematics: Results from National Assessment." Mathematics Teacher 74 (1981): 554-559. (3, 7, 39)

Fennema, Elizabeth, and Laurie H. Reyes. "Teacher/Peer Influences on Sex Differences in Mathematics Confidence." Report. October 1981. (21, 41)

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors." American Educational Research Journal 14 (1977): 51-71. (4, 28, 42)

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement and Related Factors: A Further Study." Journal for Research in Mathematics Education 9 (1978): 188-203. (30, 43)

Fox, Lynn H. "Women and Mathematics: The Impact of Early Intervention Programs upon Course-Taking and Attitudes in High School." Report. 1979. (36, 45)

Genshaft, Judy L. "The Use of Cognitive Behavior Therapy for Reducing Math Anxiety." School Psychology Review 11 (1982): 32-34. (6, 34, 44)

Giese, Elizabeth. "PEER Math Study Report." Report. 1982. (7, 39)

Good, Carter V., editor. Dictionary of Education. 3rd ed. St. Louis: McGraw-Hill Book Company, 1973. (4, 6)

Hackett, Gail. "Mathematics Self-Efficacy and the Consideration of Math-Related Majors: A Preliminary Path Model." Report. August 1981. (16, 40)

Hackett, Gail, and Nancy E. Betz. "Mathematics Self-Efficacy Expectations, Math Performance, and the Consideration of Math-Related Majors." Report. March 1982. (6, 16, 40)

Harre, Rom and Roger Lamb, editors. The Encyclopedic Dictionary of Psychology. Cambridge: MIT Press, 1983. (4)

Hendel, Darwin D. "Experiential and Affective Correlates of Math Anxiety in Adult Women." Psychology of Women Quarterly 5 (1980): 219-230. (26, 42)

Hilton, Thomas L., and Gosta W. Berglund. "Sex Differences in Mathematics Achievement - A Longitudinal Study." Journal of Educational Research 67 (1974): 231-237. (3, 30, 43)

Kincaid, Marylou Butler, and George Ausin-Martin. "Relationships Between Math Attitudes and Achievement, Parents' Occupation, and Math Anxiety in Female College Freshmen." Report. January 1981. (27, 42)

Kloosterman, Peter. "Sex-Related Differences in Students' Reactions to Failure on Algebra Word Problems." Report. 1985. (5, 31, 43)

Kostka, Marion P., and Christine K. Wilson. "Reducing Mathematics Anxiety in Nontraditional-Age Female Students." Journal of College Student Personnel 27 (1986): 530-534. (6, 33, 44)

Lewis, Mark A., and John B. Cooney. "Attributional and Performance Effects of Competitive and Individualistic Feedback in Computer Assisted Mathematics Instruction." Report. April 1986. (38, 45)

Lips, Hilary M. "Math/Science Self-Schemas and Curriculum Choices among University Women." Report. August 1984. (6, 15, 40)

Lips, Hilary M., et al. "Self-Schema Theory and Gender-Related Behaviors: Research on Some Correlates of University Women's Participation in Mathematics, Science, and Athletic Activities." Report. 1985. (15, 40)

Macfarlane, Jim, and Pat Crawford. "Effects of Sex-Segregated Mathematics Classes on Student Attitudes and Achievement in Mathematics: A.Y. Jackson Secondary School, Year 1." Report. September 1985. (33, 44)

McDermott, Marilyn. "The Impact of Classroom Interaction Patterns on Students' Achievement-Related Beliefs and Behavior." Report. April 1983. (21, 41)

McNamara, Patricia P., and Rita A. Scherrel. "College Women Pursuing Careers in Science, Mathematics, and Engineering in the 1970's." Report. May 1982. (20, 41)

Meece, Judith L. "Sex Differences in Achievement-Related Affect." Report. March 1982. (9, 39)

Moss, Jillian D. "Towards Equality: Progress by Girls in Mathematics in Australian Secondary Schools." Report. February 1982. (24, 41)

Pallas, Aaron M., and Karl L. Alexander. "Sex Differences in Quantitative SAT Performance: New Evidence on the Differential Coursework Hypothesis." American Educational Research Journal 20 (1983): 165-182. (3, 24, 41)

Parsons, Jacquelynne Eccles. "Sex Stereotyping Versus Perceived Value as the Mediator of Sex Differentiated Math Participation." Report. 1981. (4, 10, 39)

Pedersen, Katherine, Dorothy R.Bleyer, and Patricia B. Elmore. "Attitudes and Career Interests of Junior High School Mathematics Students: Implications for the Classroom." Arithmetic Teacher 32 (1985): 45-49. (4, 5, 6, 29, 42)

Pedersen, Katherine, Patricia Elmore, and Dorothy Bleyer. "Affective and Cognitive Mathematics-Related Variables: A Longitudinal Study." Report. September 1985. (19, 41)

Pedro, Joan Daniels, et al. "Election of High School Mathematics by Females and Males: Attributions and Attitudes." American Educational Research Journal 18 (1981): 207-218. (14, 40)

Perl, Teri Hoch. "Discriminating Factors and Sex Differences in Electing Mathematics." Journal for Research in Mathematics Education 13 (1982): 66-74. (4, 10, 39)

Richardson, F.C., and Richard M. Suinn. "The Mathematics Anxiety Rating Scale: Psychometric Data." Journal of Counseling Psychology 19 (1972): 551-554. (5)

Schwartz, Helga, and Sarah Papier. "A Head Start in Mathematics for Girls in Elementary School: A Pilot Study." Urban Education 19 (1985): 351-364. (34, 44)

Sells, Lucy W. "High School Math as the Critical Filter in the Job Market." Report. March 1973. (8, 39)

Senk, Sharon, and Zalman Usiskin. "Geometry Proof Writing: A New View of Sex Differences in Mathematics Ability." American Journal of Education 91 (1983): 187-201. (25, 42)

Shanklin, Garth R. "Escape from Mathematics Anxiety as a Factor in Major Choice." Report. 1978. (14, 40)

Sherman, Julia. "Mathematics, Spatial Visualization, and Related Factors: Changes in Girls and Boys, Grades 8-11." Journal of Educational Psychology 72 (1980): 476-482. (3, 29, 39, 42)

Sherman, Julia. "Continuing in Mathematics: A Longitudinal Study of the Attitudes of High School Girls." Psychology of Women Quarterly 7 (1982a): 132-140. (12, 40)

Sherman, Julia. "Mathematics the Critical Filter: A Look at Some Residues." Psychology of Women Quarterly 6 (1982b): 428-444. (1, 2, 11, 40)

Sherman, Julia. "Factors Predicting Girls' and Boys' Enrollment in College Preparatory Mathematics." Psychology of Women Quarterly 7 (1983a): 272-281. (12, 40)

Sherman, Julia. "Girls Talk About Mathematics and Their Future: A Partial Replication." Psychology of Women Quarterly 7 (1983b): 338-342. (9, 39)

Sherman, Julia, and Elizabith Fennema. "The Study of Mathematics by High School Girls and Boys: Related Variables." American Educational Research Journal 17 (1977): 159-168. (13, 40)

Skolnick, Joan, and Carol Langbort, and Lucille Day. How to Encourage Girls in Math and Science. Palo Alto: Dale Seymour Publications, 1982. (4, 6)

Stallings, Jane, and Anne Robertson. "Factors Influencing Women's Decisions to Enroll in Advanced Mathematics Courses." Report. May 1979. (18, 41)

Thomas, Gail E. "Cultivating the Interest of Women and Minorities in High School Mathematics and Science." Science Education 70 (1986): 31-43. (1, 2, 17, 40)

Trent, Richard M. "Hypnotherapeutic Restructuring and Systematic Desensitization as Treatment for Mathematics Anxiety." Report. April 1985. (4, 5, 35, 44)

Van Der Werf, Greetje. "Girls and Mathematics: The New Math Program." Report. April 1986. (38, 45)

Visser, Delene. "Sex Differences in Mathematics Achievement and Participation." Report. April 1986. (18, 41)

Weiner, Neil C., and Sharon E. Robinson. "Cognitive Abilities, Personality, and Gender Differences in Math Achievement of Gifted Adolescents." Report. 1983. (32, 43)

Wooley, Daniel. "The Effects of Sex and Anxiety on Mathematics Performance." Report. 1982. (28, 42)